Attorney Docket No. LKMP:112US

APPARATUS FOR VARYING VESSEL HULL GEOMETRY AND VESSELS MADE THEREWITH

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit under 35 U.S.C. §119(e) of United States Provisional Application No. 60/442,129, filed January 24, 2003.

FIELD OF THE INVENTION

[0002] This invention relates to the construction of vessels. More specifically it relates to an apparatus for the construction of vessels having variable sized hulls. Even more specifically, the present invention relates to a vessel having a hull whose size and shape can be modified without refitting the vessel.

BACKGROUND OF THE INVENTION

[0003] Waterborne and submersible vessels are typically constructed having a hull of fixed dimensions. This fixes various characteristics of the vessel, such as the capacity, maneuverability, and stability of the vessel. If a vessel owner wishes to modify any of these characteristics, a major overhaul is typically required. This typically involves significant cost in resources and time.

[0004] Clearly, then, there is a longfelt need for a vessel having a hull with variable dimensions.

SUMMARY OF THE INVENTION

[0005] The present invention broadly comprises a method and apparatus for varying the dimensions of a vessel hull comprising an assembly having a plurality of members pivotally

joined. The assembly is operatively arranged to form a portion of the vessel hull. The assembly is operatively arranged to extend and retract to vary the dimensions of the hull when the plurality of members are pivoted with respect to one another.

[0006] A general object of the present invention is to provide an apparatus for varying the dimensions of a vessel hull.

[0007] Another object of the present invention is to change the carrying capacity, buoyancy, maneuverability, stability, and/or resistance of the vessel.

[0008] These and other objects, features and advantages of the present invention will become readily apparent to those having ordinary skill in the art upon a reading of the following detailed description of the invention in view of the drawings and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The nature and mode of operation of the present invention will now be more fully described in the following detailed description of the invention taken with the accompanying drawing figures, in which:

Figure 1 is a perspective view of a first embodiment of the present invention installed integral with a vessel hull;

Figure 2 is a side view of the present invention installed integral with a hull of a vessel;

Figure 3A is a side view of the present invention in a retracted configuration;

Figure 3B is a side view of the present invention in an extended configuration;

Figure 4A is a side view of the assembly of the present invention in a retracted configuration;

Figure 4B is a side view of the assembly of the present invention in an extended configuration, having a membrane attached to an inner portion;

Figure 4C is a side view of the assembly of the present invention in an extended configuration;

Figure 4D is a side view of the assembly of the present invention in an extended configuration, covered by a membrane;

Figure 5A is a top view of a second embodiment of the present invention, in a fully extended configuration;

Figure 5B is a top view of the second embodiment of the present invention, in a partially extended configuration;

Figure 5C is a top view of the second embodiment of the present invention, in a fully retracted configuration;

Figure 6A is a top view of a third embodiment of the present invention covered by a membrane, in a fully extended configuration;

Figure 6B is a top view of the third embodiment of the present invention covered by a membrane, in a partially extended configuration;

Figure 6C is a top view of the third embodiment of the present invention covered by a membrane, in a fully retracted configuration;

Figure 7A is a top view of a fourth embodiment of the present invention covered by a plurality of plates, in a fully extended configuration;

Figure 7B is a top view of the fourth embodiment of the present invention covered by a plurality of plates, in a partially extended configuration;

Figure 7C is a top view of the fourth embodiment of the present invention covered by a plurality of plates, in a fully retracted configuration;

Figure 8A is a side view of the fourth embodiment of the present invention mounted on a portion of a vessel hull and fully extended;

Figure 8B is a side view of the fourth embodiment of the present invention mounted on a portion of a vessel hull and fully extended;

Figure 9A is a side view of a fifth embodiment of the present invention mounted on a portion of a vessel hull and fully extended;

Figure 9B is a side view of the fifth embodiment of the present invention mounted on a portion of a vessel hull and fully extended;

Figure 10 is a side view of a sixth embodiment of the present invention mounted on a portion of a hull of an airship;

Figure 11 is a side view of the sixth embodiment with the assemblies of the present invention fully retracted;

Figure 12 is a rear view of a seventh embodiment of the present invention, showing the assemblies fully extended;

Figure 12A is a side view of the seventh embodiment of the present invention, showing the assemblies fully extended;

Figure 13 is a rear view of the seventh embodiment of the present invention, showing the assemblies fully retracted;

Figure 14 is a front view of an eighth embodiment of the present invention, showing the spherical assembly fully extended; and,

Figure 15 is a front view of the eighth embodiment of the present invention, showing the spherical assembly fully retracted.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0010] It should be appreciated that, in the detailed description of the invention which follows, like reference numbers on different drawing views are intended to identify identical structural elements of the invention in the respective views.

[0011] A first embodiment of the present invention is shown in Figure 1 and designated 10. The invention comprises an assembly for changing the dimensions of a vessel hull. The assembly may be a radial extension/retraction truss structure as disclosed by United States Patent No. 5,024,031 (Hoberman), incorporated by reference herein. As shown in Figure 1, the assemblies are mounted on hull sections 12, 14, 18, and 20 of vessel 16. The assemblies are covered by membrane 40, and are not visible in Figure 1. Figure 4B shows assembly 38 in an extended configuration with the membrane not shown. Figure 4D shows extended assembly 38 beneath a cutaway of membrane 40.

[0012] It should be readily apparent to one skilled in the art that the assemblies of the present invention can be extended and retracted by pneumatic, hydraulic, microelectromechanical systems (MEMS), or any other means known in the art. Assemblies actuated by any means known in the art are intended to be within the spirit and scope of the invention as claimed.

[0013] Figure 2 shows portion 22 of a hull of a vessel having hull extension 24. Apparatus 10 is located on the forward section of hull extension 24. Membrane 40 is shown covering the assembly of the present invention. The membrane is shown in solid lines for a fully

retracted configuration of the assembly and in broken lines for a fully extended configuration of the assembly.

[0014] Figures 3A and 3B illustrate the buoyancy gain realized by the vessel when the membrane is sealed to the hull with a watertight seal. Membrane 40 is shown covering the assembly in the fully retracted position in Figure 3A. Membrane 40 is connected to hull portion 34. The waterline 32 is relatively high with respect to hull 30. Figure 3B shows membrane 40 covering the assembly in a fully extended configuration. The expansion of the vessel volume below the waterline 32 increases the buoyancy of the vessel. This leads to the vessel rising in the water. Thus, waterline 32 is relatively lower on hull 30.

[0015] In addition, the expansion and contraction of the assembly will change the magnitude of the wave-making drag created by the hull moving through the water (corresponding to the change in the Froude number). Thus, in some applications, the extent to which the assembly is extended or contracted may be determined by the optimal Froude number (the Froude number resulting in minimum drag for a desired speed) resulting from the assembly size, rather than the buoyancy created by the assembly size.

[0016] The watertight embodiment shown in Figures 3A and 3B may also be used to compensate for vessel internal (payload) or external environmental moments by extending the different assemblies shown in Figure 1 to different configurations. If each assembly is extended to a different configuration, each of the assemblies creates a different amount of buoyancy. This allows the operator of the vessel to rebalance the vessel for loading or unloading, passenger crowding, turning, wind, and icing, for example.

[0017] Figures 3A and 3B show an embodiment that varies the hull geometry while maintaining a watertight seal, thus changing the buoyancy of the hull. However, a watertight seal is not necessary. The apparatuses 10 in Figure 1 may be mounted on watertight hull portions, which would fix the buoyancy of the vessel. A membrane or plurality of plates would still be necessary to substantially inhibit the free flow of fluid through the apparatus 10. In this case, the extension and contraction of the assembly would serve only to change the Froude number, changing the magnitude of the drag created. In this case, the configuration of the assembly would be determined solely by the optimal Froude number (the Froude number that minimizes drag at the desired speed). Configurations of the present invention either with a watertight seal or without a watertight seal are both within the spirit and scope of the invention as claimed.

[0018] Figures 1-3 show a membrane covering the assembly of the present invention. However, the membrane may be connected to an inner portion of the assembly, exposing the assembly to the water. In either case, the membrane may be connected to the hull with a watertight seal. Figure 4A shows assembly 38 in a retracted position. In one embodiment, membrane 40 is connected to an inner portion of assembly 38, such that it expands as assembly 38 extends (shown in Figure 4C). It should be readily apparent to one skilled in the art that a membrane may be located within the assembly, covering the assembly, or a membrane may be located both inside the assembly and covering the assembly, and these modifications are intended to be within the spirit and scope of the invention as claimed.

[0019] A second exemplary embodiment of the present invention is shown in Figures 5A-5C and designated 110. This embodiment is an iris-type assembly that covers an aperture in the hull when fully extended, and exposes the aperture in the hull when fully retracted. Figure 5A

shows assembly 38 in a fully extended configuration. Figure 5B shows the assembly in a partially extended configuration. Figure 5C shows the assembly in a fully retracted configuration.

[0020] The assembly may be covered by a flexible membrane, as illustrated in Figures 6A-6C. Figure 6A shows embodiment 210 comprising fully extended assembly 38 covered by membrane 40. Membrane 40 has an aperture 42 in the center, which is substantially closed when the assembly is fully extended. Figure 6B shows assembly 38 partially retracted, opening aperture 42. Figure 6C shows assembly 38 fully retracted, opening aperture 42 to its widest extent.

[0021] In embodiment 310, a non-circular assembly 74 is covered with plates as shown in Figures 7A-7C. Figure 7A shows embodiment 310 comprising fully extended assembly 74 partially covered by a plurality of plates 44. When assembly 74 is retracted, plates 44 are also retracted, forming an aperture. Figure 7B shows assembly 74 partially retracted, with the plurality of plates partially retracted. Figure 7C shows assembly 74 fully retracted, retracting plates 44 to their greatest extent. As should be readily apparent to one skilled in the art, other means of covering an iris-type assembly are possible, and these modifications are intended to be within the spirit and scope of the invention as claimed. For example, the plates or membrane may or may not be watertight when the assembly is fully extended. A watertight seal is not required for an aperture such as a bow thruster, as there is a watertight seal within the aperture. The present invention would serve to decrease drag when it is fully extended and the vessel is moving. However, the present invention could serve to both reduce drag and provide a watertight seal for an aperture in a vessel hull.

[0022] Figure 8A shows an iris-type assembly mounted on hull portion 78 of hull 76. The assembly is covered by plates 44 and is fully extended. Figure 8B shows assembly 74 fully retracted, forming aperture 75. Aperture 75 faces the forward direction of the hull. This embodiment may be used to cover, for example, a torpedo tube. However, any aperture in a hull may be covered in this manner.

[0023] Figures 9A and 9B illustrate a fifth exemplary embodiment of the present invention. Hull 76 comprises apparatus 310. Apparatus 310 is an iris-type assembly covered by plates 44. Apparatus 310 covers an aperture in hull 76 containing bow thruster 90. When bow thruster 90 is needed to maneuver the vessel, apparatus 310 is retracted to reveal aperture 75. When the bow thruster is no longer needed, apparatus 310 is extended to cover aperture 75, reducing the drag that would result from exposing aperture 75 during normal travel. An aperture for a water-jet, turbine, or any other aperture in a hull may be covered by apparatus 310 in a similar fashion.

[0024] It should be readily apparent to one skilled in the art that the present invention may be used to vary the geometry of hulls of both waterborne and submersible vessels. Variable hulls for both waterborne and submersible vessels are intended to be within the spirit and scope of the invention as claimed. In addition, the invention could be used to vary the geometry of aircraft, including, for example, airships. Figures 10-15 illustrate the use of the present invention to vary the dimensions of aircraft.

[0025] Figure 10 shows airship 412 having passenger compartment 414. A variable hull section 410 is connected to the front and the back of the airship. Assembly 438 (shown beneath a cutaway) is covered by flexible membrane 440. Assembly 438 expands and contracts to change

the dimensions of the hull of the vessel. (Both front and rear assemblies are shown fully extended in Figure 10.) Vertical stabilizers 416 and horizontal stabilizers 420, as well as fins 418, are constructed to allow assembly 438 to expand and contract while the fins are moved to any position.

[0026] Figure 11 shows the front and rear assemblies fully contracted. This reduces the displacement of air by the vessel. As with the previously discussed embodiments, there can be a flexible membrane over the assembly, within the assembly, or both over the assembly and within the assembly. The membrane may be used to contain a lighter-than-air fluid, or may simply bound the interior of the vessel. (In the latter case, a lighter-than-air fluid is held in containers within the hull of the aircraft.) All of the above embodiments are within the spirit and scope of the invention as claimed.

[0027] Figures 12, 12A, and 13 show a vessel 512 having an ellipsoidal assembly 538 that extends and retracts conformally. Figure 12 is a rear view of airship 512 with assembly 538 (shown beneath a cutaway of membrane 540) in a fully expanded configuration. Passenger compartment 514 is connected to the lower portion of the airship. Horizontal stabilizers 520 and vertical stabilizers 516 are connected to the assembly, and move relative to the passenger compartment when the assembly extends or retracts. Fins 518 may be fixed in size or also composed of assemblies 538. They are free to move throughout the desired dynamic range regardless of the extent to which the hull assemblies are extended or retracted. As stated above, a flexible membrane covers the assemblies, is within the assemblies, or both. The membranes may be airtight, allowing the lighter-than-air fluid to be bounded by the membrane(s), or the lighter-than-air fluid may be held in containers within the membrane(s).

[0028] Figures 14 and 15 show aircraft 612 comprising a spherical hull 610. The spherical hull is an assembly 638 (shown beneath a cutaway of membrane 640) covered by membrane 640. Passengers may ride within compartment 614. As with previous embodiments, the lighter-than-air fluid may be contained within airtight membranes covering, within, or both covering and within the assembly. The lighter-than-air fluid may instead be held within containers within the hull.

[0029] Thus, it is seen that the objects of the present invention are efficiently obtained, although modifications and changes to the invention should be readily apparent to those having ordinary skill in the art, and these modifications are intended to be within the spirit and scope of the invention as claimed.